

1121

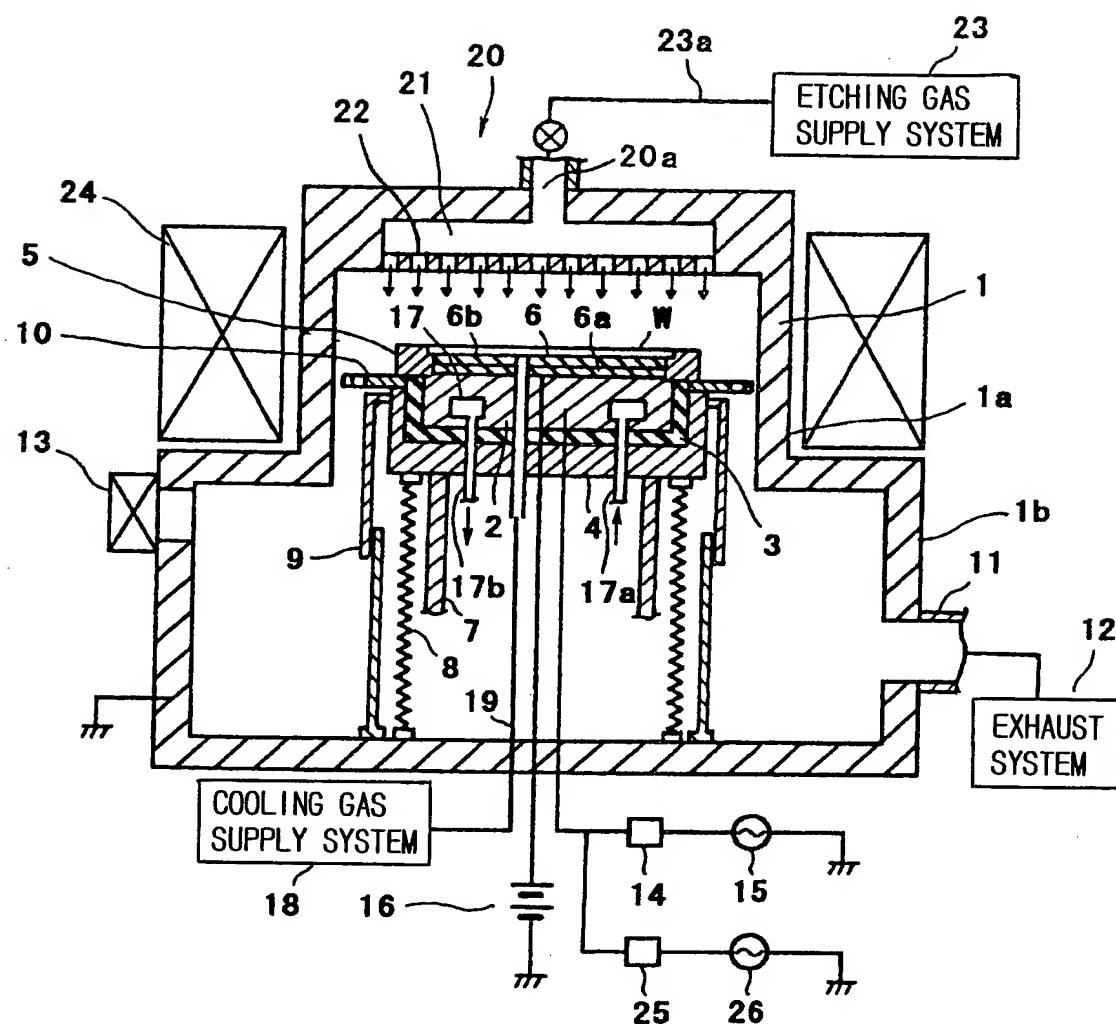


FIG. 1

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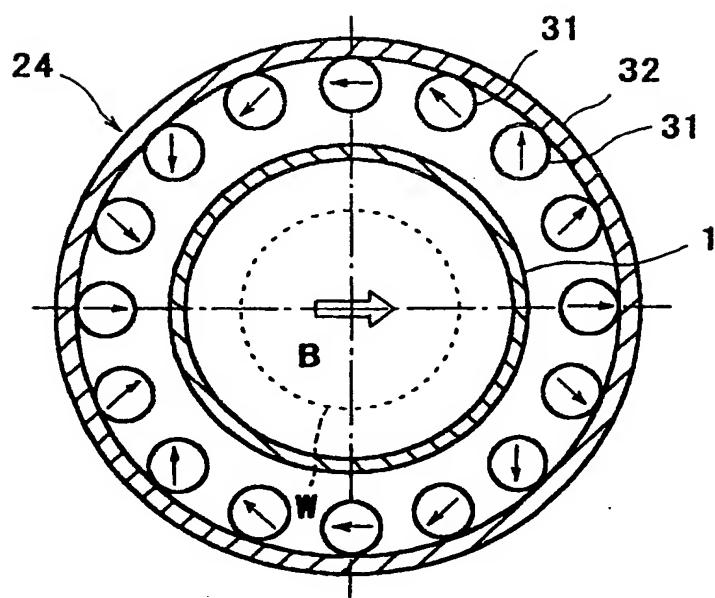


FIG. 2

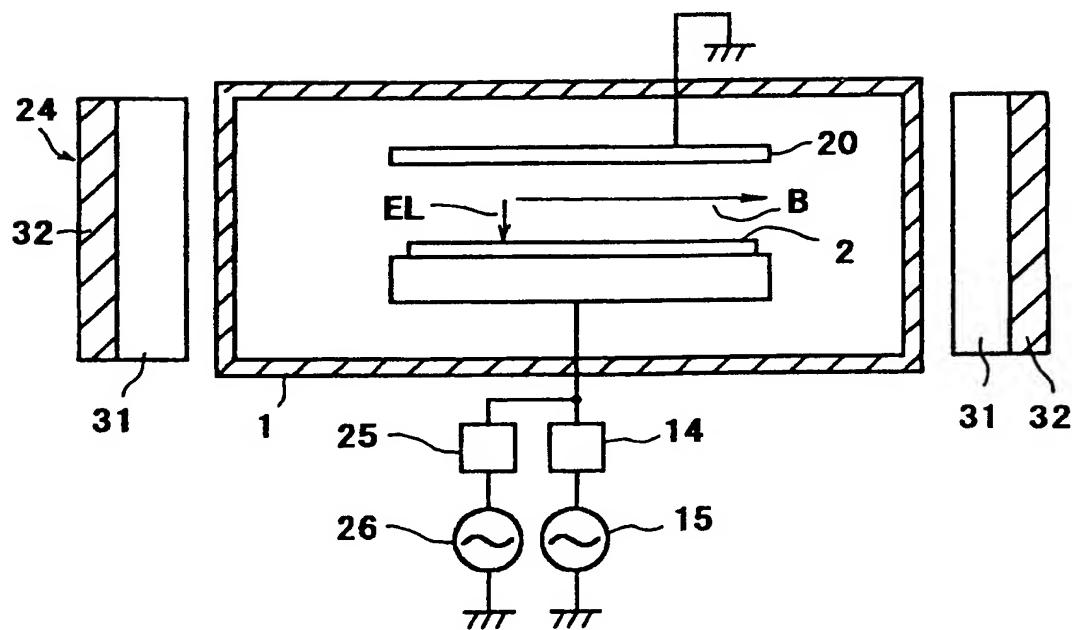


FIG. 3

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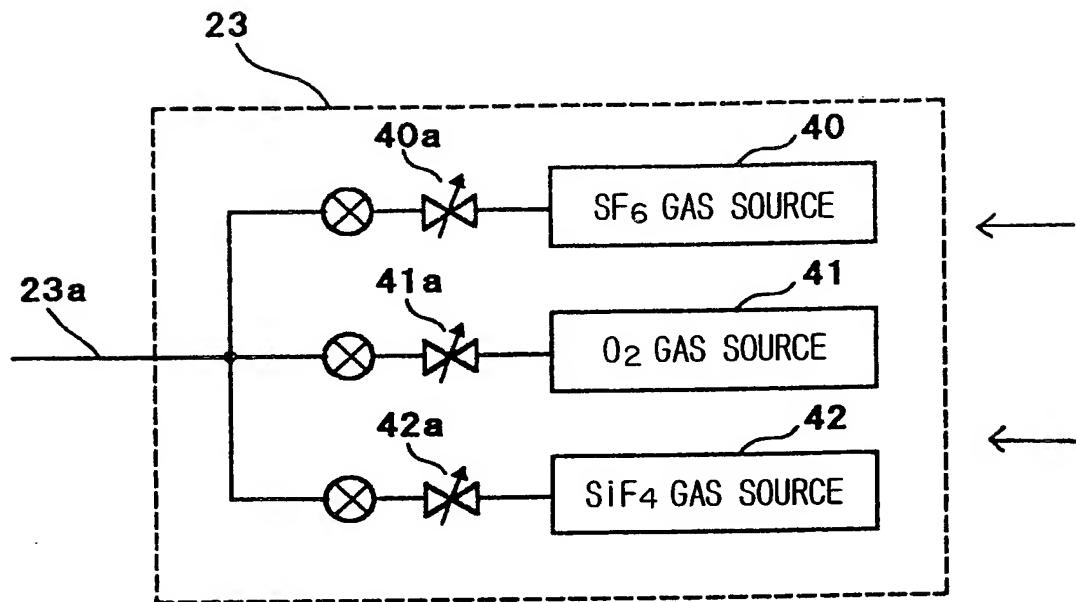


FIG. 4

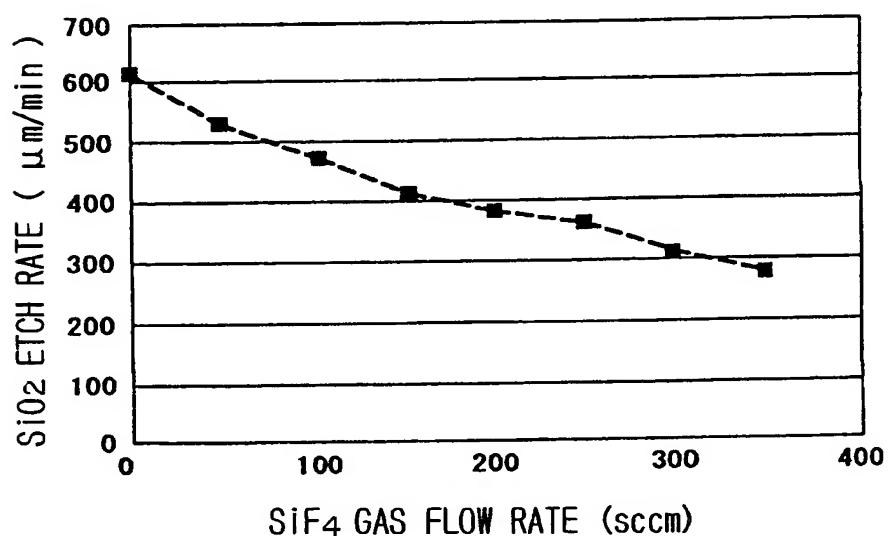
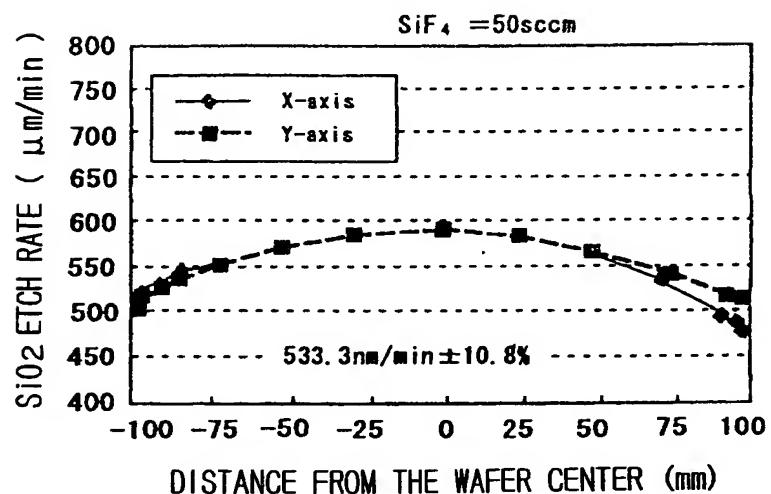


FIG. 5

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(a)



(b)

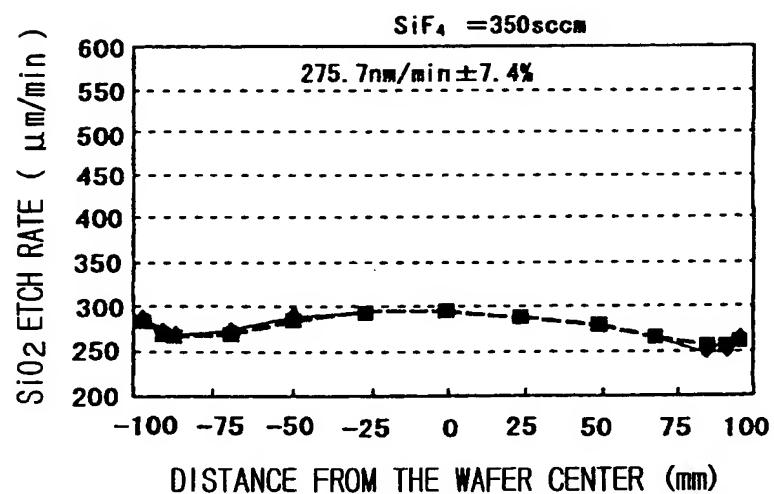


FIG. 6

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5 μ m ϕ TRENCH ETCH

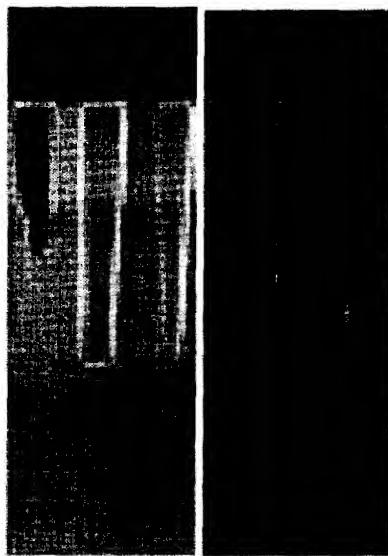
	ETCHING GAS FLOW RATE (sccm)	Si E/R (μ m/min)		SiO ₂ E/R ($\text{\AA}/\text{min}$)		Si ETCH SELECTIVITY		UNDERCUT (μ m/min)		TAPER ANGLE (deg.)	
		CEN-TER	EDGE	CEN-TER	EDGE	CEN-TER	EDGE	CEN-TER	EDGE	CEN-TER	EDGE
COMPARATIVE EXAMPLE a1	SF ₆ /O ₂ (400/75)	19.8	19.5	6290	6498	31.4	30.0	0.42	0.20	88.99	89.02
EXAMPLE A1	SF ₆ /O ₂ /SiF ₄ (200/40/250)	14.8	14.6	4636	4899	31.9	29.8	0.23	0.19	-	-
EXAMPLE A2	SF ₆ /O ₂ /SiF ₄ (200/80/250)	15.4	15.1	3463	3847	44.4	39.2	0	0	-	-
EXAMPLE A3	SF ₆ /O ₂ /SiF ₄ (200/160/250)	15.6	15.2	3377	3737	46.1	40.7	0	0	88.74	88.31
EXAMPLE A4	SF ₆ /O ₂ /SiF ₄ (400/80/250)	17.2	16.9	5468	5192	31.5	32.6	0.37	0.33	-	-
EXAMPLE A5	SF ₆ /O ₂ /SiF ₄ (400/160/250)	17.4	17.5	4581	4708	38.0	37.1	0	0	-	-
EXAMPLE A6	SF ₆ /O ₂ /SiF ₄ (600/240/250)	17.5	17.6	5045	4920	34.7	35.7	0	0	-	-

FIG. 7

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[COMPARATIVE EXAMPLE a1]

(CENTER) (EDGE)



ENLARGED VIEW OF A PART NEAR THE MASK

(CENTER) (EDGE)

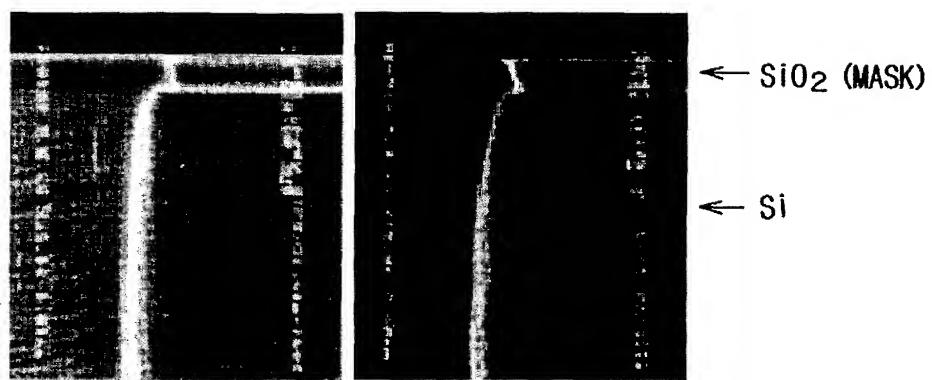
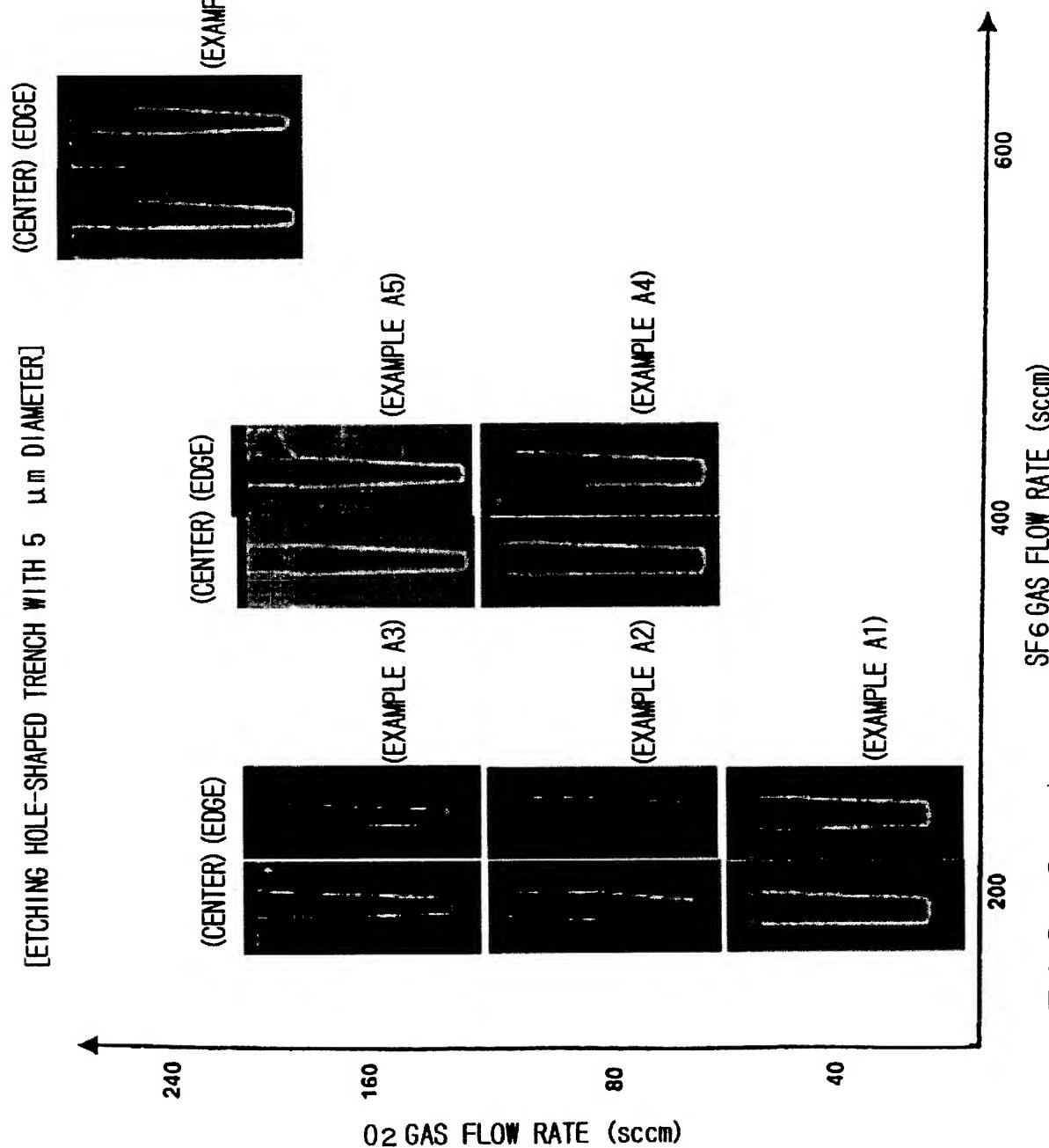


FIG. 8

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ENLARGED VIEW OF A PART NEAR THE MASK

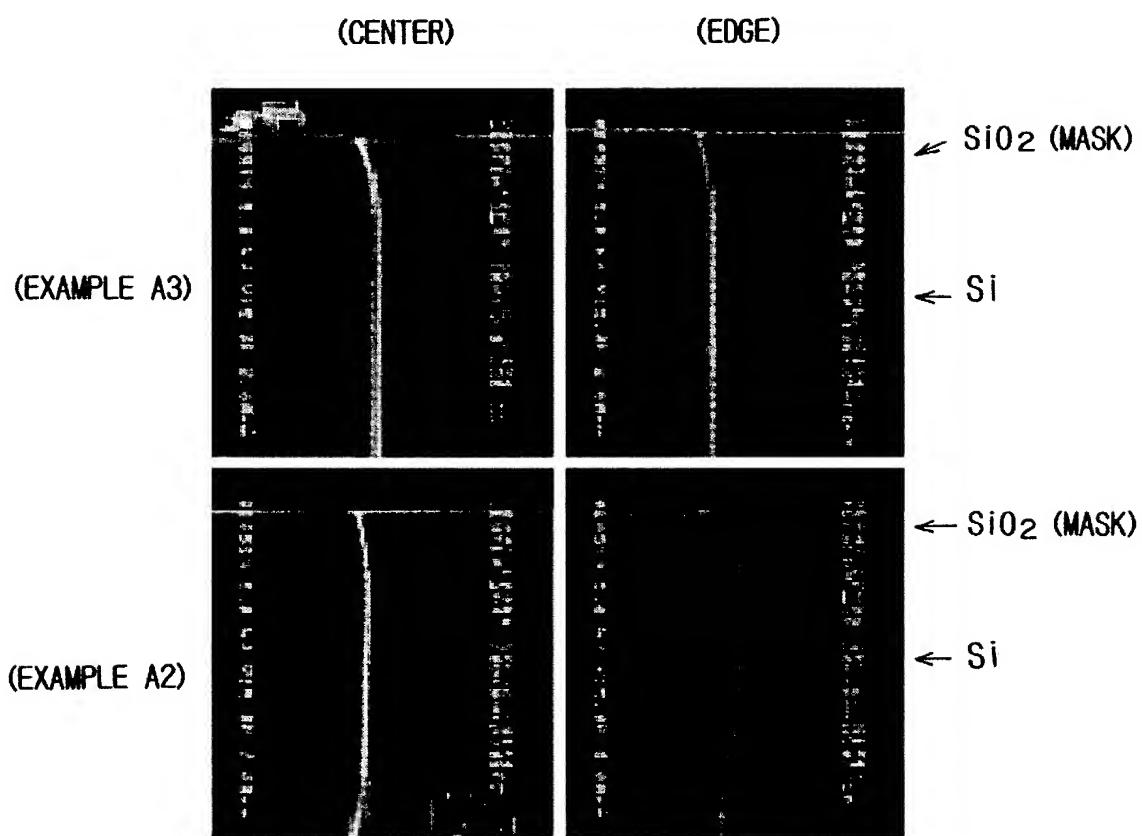


FIG. 10

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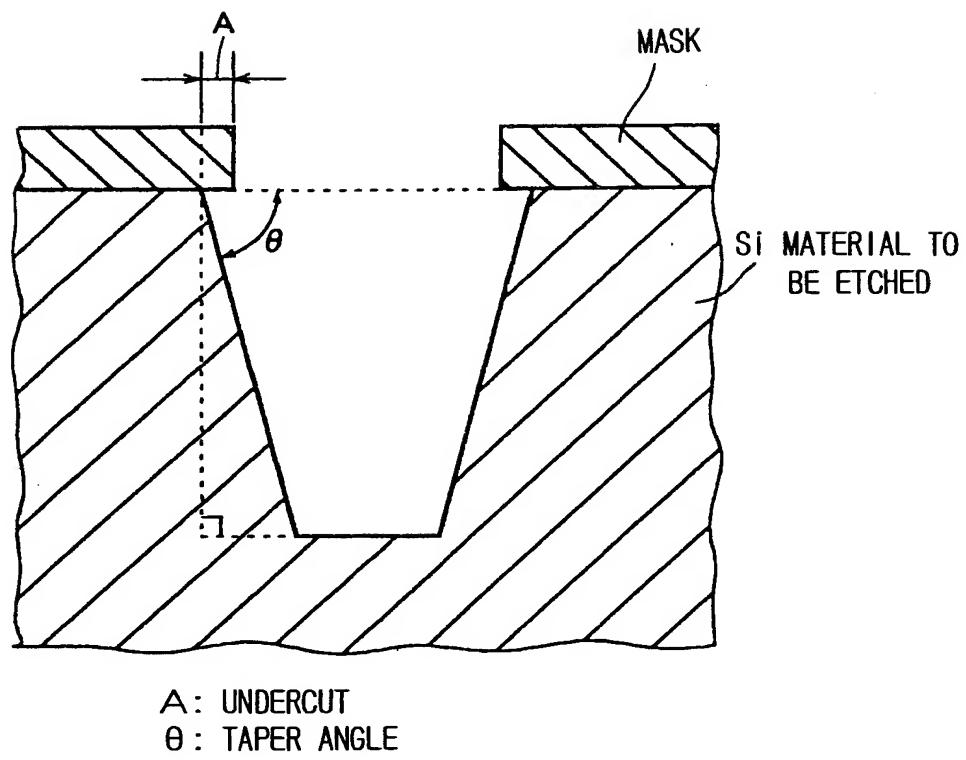


FIG. 11

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20 μm TRENCH ETCH

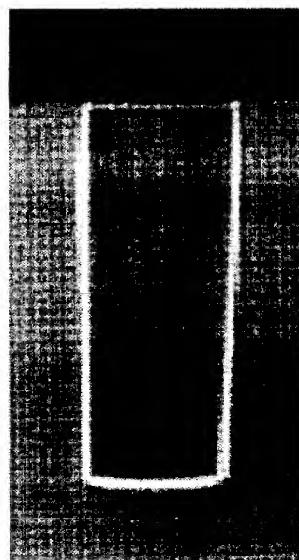
	ETCHING GAS FLOW RATE (sccm)	Si E/R ($\mu\text{m}/\text{min}$)		SiO ₂ E/R ($\text{\AA}/\text{min}$)		Si ETCH SELECTIVITY		UNDERCUT ($\mu\text{m}/\text{min}$)		TAPER ANGLE (deg.)	
		CEN- TER	EDGE	CEN- TER	EDGE	CEN- TER	EDGE	CEN- TER	EDGE	CEN- TER	EDGE
COMPA- RATIVE EXAMPLE b1	SF ₆ /O ₂ (400/75)	28.9	28.3	6290	6498	46.0	43.5	0.74	0.39	89.33	89.14
EXAMPLE B1	SF ₆ /O ₂ /SiF ₄ (200/40/250)	20.9	21.0	4636	4899	45.1	42.9	—	—	—	—
EXAMPLE B2	SF ₆ /O ₂ /SiF ₄ (200/80/250)	21.5	21.0	3463	3847	62.1	54.6	0	0	—	—
EXAMPLE B3	SF ₆ /O ₂ /SiF ₄ (200/160/250)	15.4	14.2	3377	3737	45.5	38.1	—	—	—	—
EXAMPLE B4	SF ₆ /O ₂ /SiF ₄ (400/80/250)	24.6	23.9	5468	5192	45.1	46.0	—	—	—	—
EXAMPLE B5	SF ₆ /O ₂ /SiF ₄ (400/160/250)	23.2	23.3	4581	4708	50.6	49.5	—	—	—	—
EXAMPLE B6	SF ₆ /O ₂ /SiF ₄ (600/240/250)	22.8	22.7	5045	4920	45.2	46.2	—	—	—	—

FIG. 12

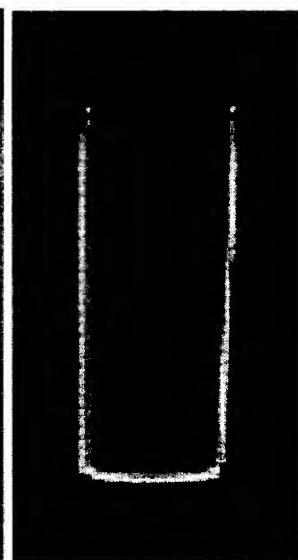
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[COMPARATIVE EXAMPLE b1]

(CENTER)

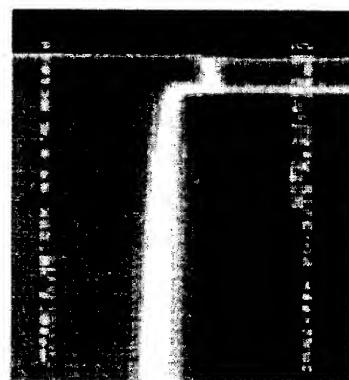


(EDGE)

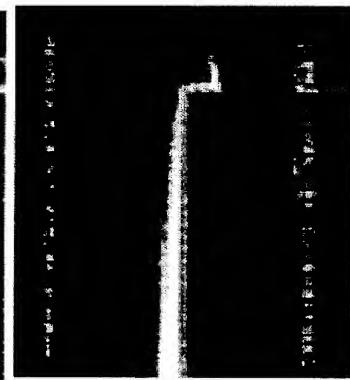


ENLARGED VIEW OF A PART NEAR THE MASK

(CENTER)



(EDGE)



← SiO₂ (MASK)

← Si

FIG. 13

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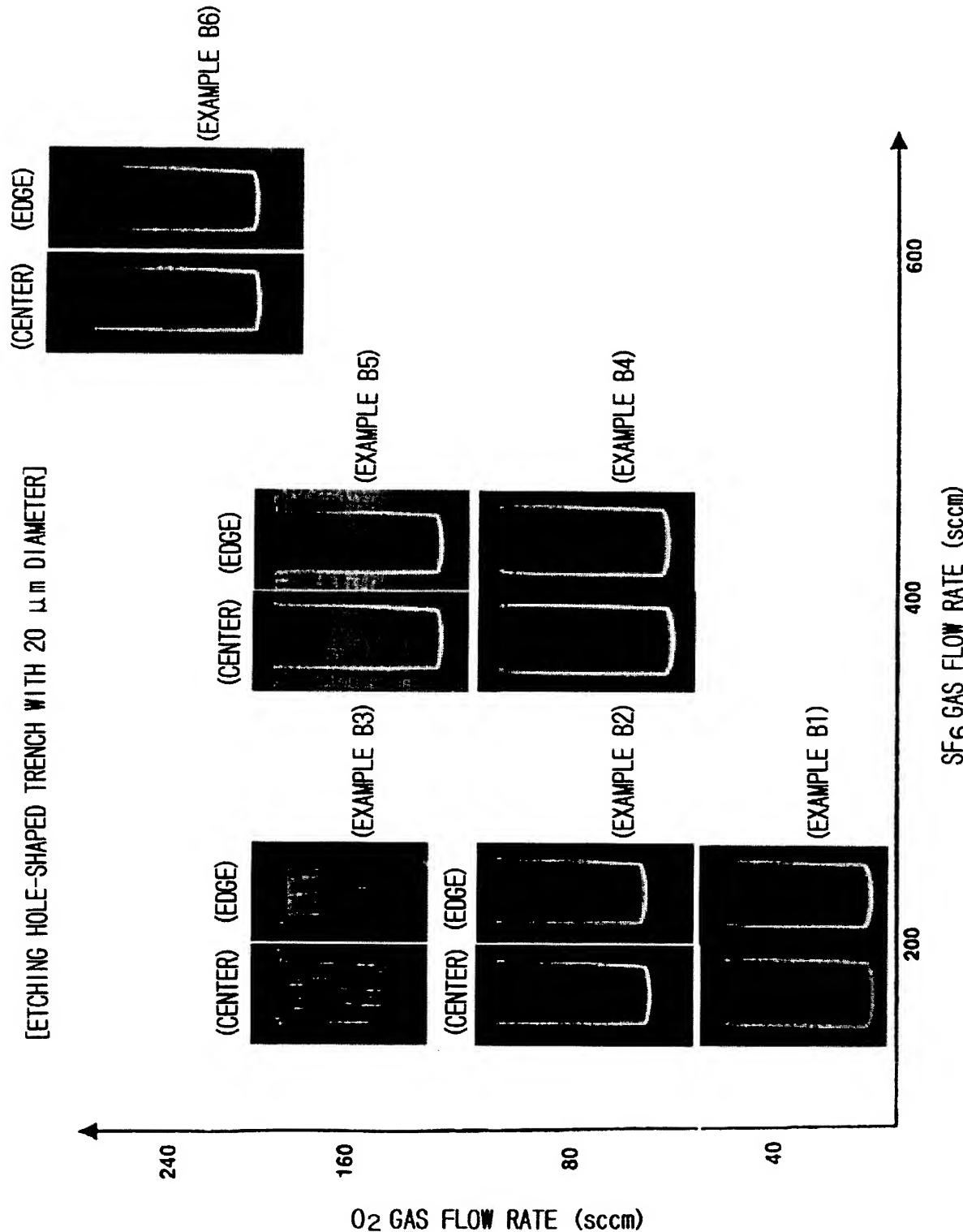


FIG. 14

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ENLARGED VIEW OF A PART NEAR THE MASK

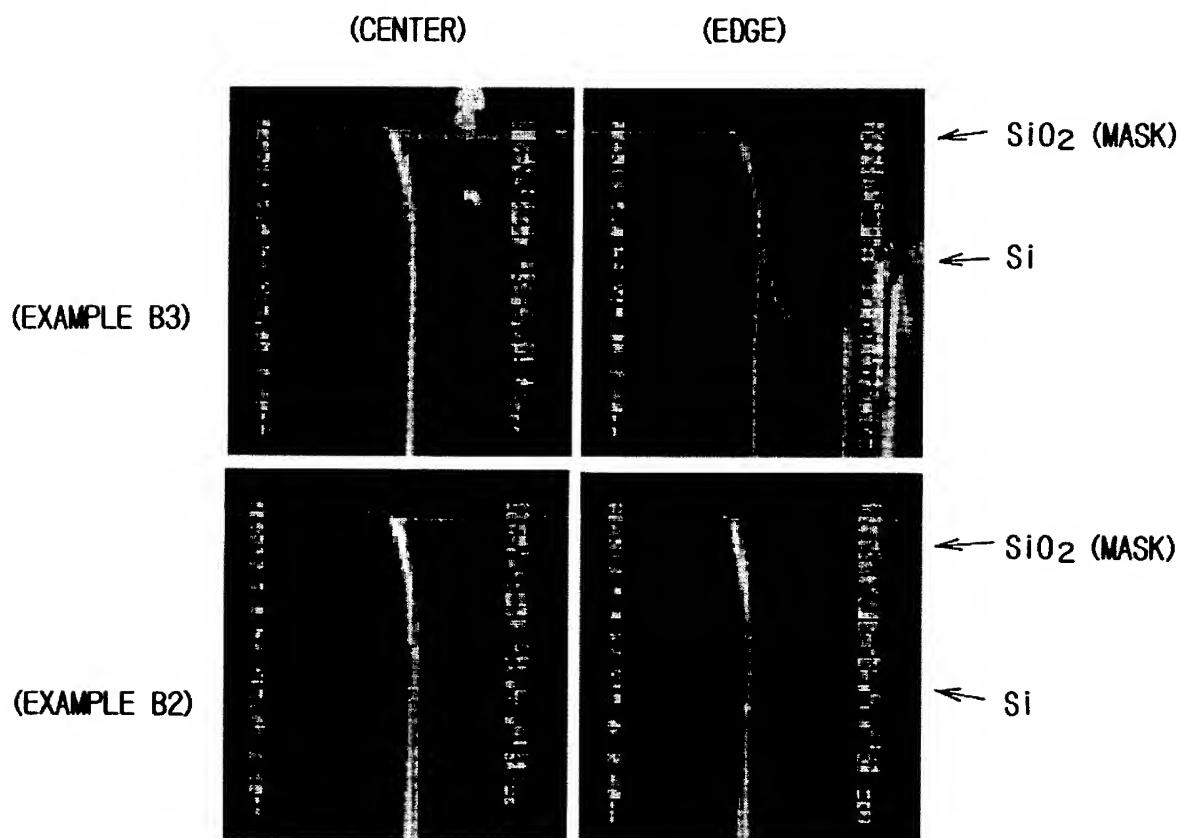


FIG. 15

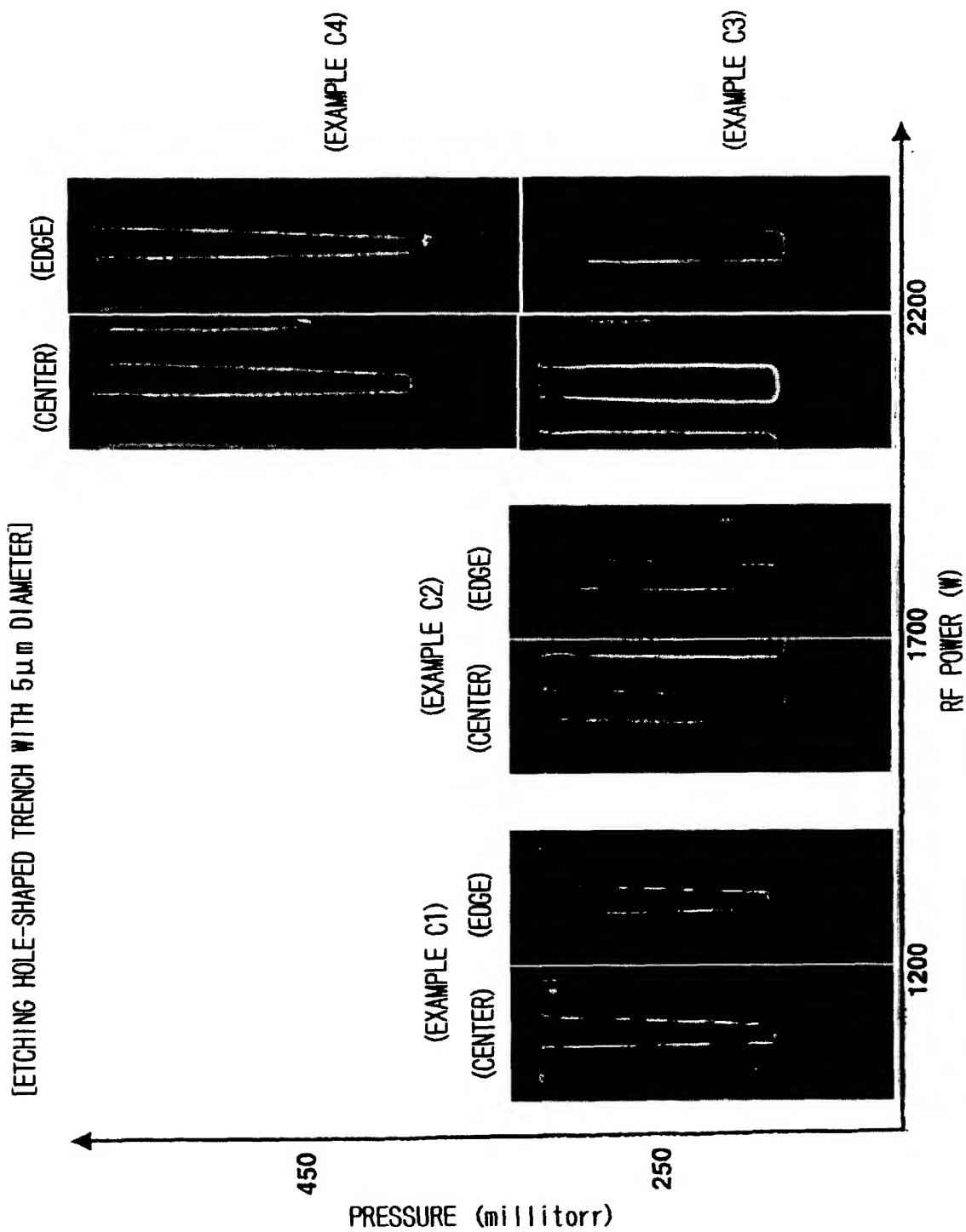
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5 μ m ϕ TRENCH ETCH

	RF POWER (W)	PRES- SURE (mTorr)	Si E/R (μ m/min)		SiO ₂ E/R (\AA /min)		Si ETCH SELECTIVITY		TAPER ANGLE (deg.)	
			CEN- TER	EDGE	CEN- TER	EDGE	CEN- TER	EDGE	CEN- TER	EDGE
EXAMPLE C1	1200	250	15.6	15.2	3377	3737	46.1	40.7	88.74	88.31
EXAMPLE C2	1700	250	16.1	16.0	3663	4308	44.1	37.0	90.00	89.80
EXAMPLE C3	2200	250	15.7	16.3	3513	3850	44.6	42.4	91.09	–
EXAMPLE C4	2200	450	21.0	21.2	3717	4848	56.6	43.8	89.09	88.70

FIG. 16

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20 μ m ϕ TRENCH ETCH

	RF POWER (W)	PRES- SURE (mTorr)	Si E/R (μ m/min)	CEN- TER	SiO ₂ E/R ($\text{\AA}/\text{min}$)	CEN- TER	Si ETCH SELECTIVITY
			EDGE	EDGE	EDGE	EDGE	EDGE
EXAMPLE D1	1200	250	15.4	14.2	3377	3737	45.5
EXAMPLE D2	1700	250	18.7	17.2	3663	4308	51.1
EXAMPLE D3	2200	250	20.4	17.9	3513	3850	58.1
EXAMPLE D4	2200	450	28.6	26.3	3717	4848	76.9
							54.2

FIG. 18

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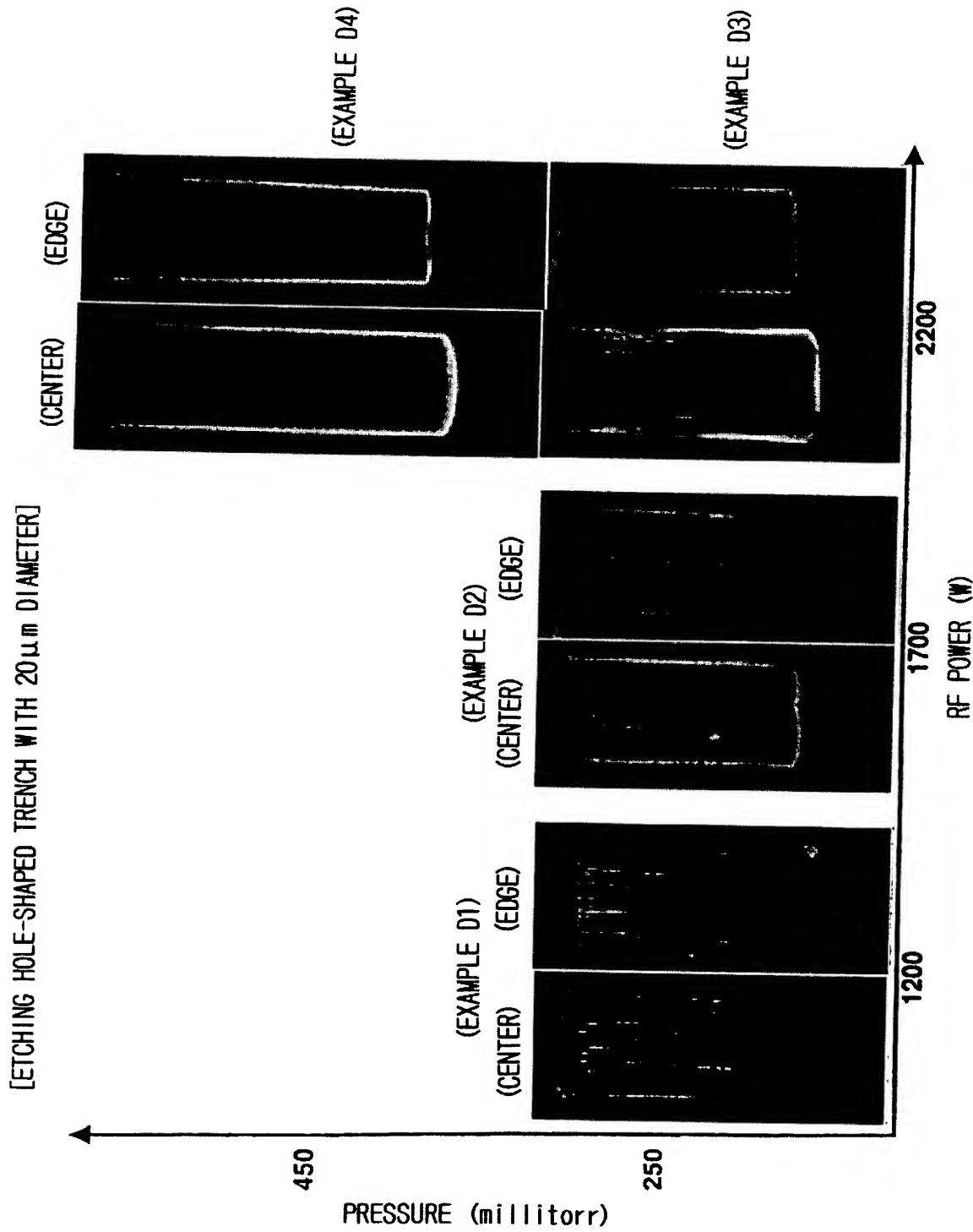


FIG. 19

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3 μ m ϕ TRENCH ETCH WITH RESIST MASK

EXAMPLE	RF POWER (w)	PRESSURE (mTorr)	O ₂ FLOW RATE (sccm)	Si E/R (μ m/min)		RESIST E/R ($\text{\AA}/\text{min}$)	Si ETCH SELECTIVITY	NOTE
				CENTER	EDGE			
F1	450	130	120	6.5	6.6	4118	3016	21.8 STEPS ARE FORMED ON SIDEWALLS OF TRENCHES
F2	700	230	120	10.33	10.71	6348	5475	16.3 19.6
F3	1000	350	120	12.48	13.08	8796	8538	14.2 15.3 SLIGHTLY INVERSELY TAPERED
F4	1000	350	180	15.72	16.02	8963	9144	17.5 17.5 SLIGHTLY BOWING

FIG. 20

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1.2 μ m-WIDTH TRENCH ETCH

ETCHING GAS FLOW RATE (sccm)	PRES-SURE (mTorr)	RF POWER (W)	BACK PRESSURE (Torr)	TIME (sec)	LOCA-TION	TRENCH LENGTH	Si ETCH SELEC-TIVITY (Si/SiO ₂)	Si E/R (μ m/min)	TAPER ANGLE (deg)
COMPARE-ATIVE EXAMPLE 1	SF ₆ /O ₂ (150/90)	70	650	7	CEN-TER	1 μ m	21.2	5.72	88.3
				40	EDGE	2 μ m	22.4	6.05	
				60		10 μ m	24.2	6.54	87.7
COMPARE-ATIVE EXAMPLE e2	SF ₆ /O ₂ (150/90)	100	650	10	CEN-TER	1 μ m	31.9	6.30	87.3
				40	EDGE	2 μ m	35.0	6.91	
				60		10 μ m	37.0	7.30	86.9
COMPARE-ATIVE EXAMPLE e3	SF ₆ /O ₂ (150/90)	70	500	15	CEN-TER	1 μ m	21.3	6.28	87.5
				40	EDGE	2 μ m	24.4	7.19	
				60		10 μ m	24.7	7.27	86.8
						1 μ m	32.0	5.76	86.7
						2 μ m	36.7	6.60	
						10 μ m	36.8	6.62	86.4
							1 μ m	21.0	4.84
							2 μ m	24.4	5.62
							10 μ m	24.8	5.71
							1 μ m	35.5	4.61
							2 μ m	40.8	5.30
							10 μ m	41.1	5.34
									85.7

FIG. 21

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1.2 μ m-WIDTH TRENCH ETCH

ETCHING GAS FLOW RATE (scm)	PRES- SURE (mTorr)	RF POWER (W)	BACK PRESSURE (Torr)	TIME (sec)	LOCA- TION	TRENCH LENGTH	Si ETCH SELEC- TIVITY (Si/SiO ₂)	Si E/R (μ m/ min)	TAPER ANGLE (deg)
									1 μ m
EXAMPLE E1	SF ₆ /O ₂ / SiF ₄ (150/90 /50)	70	650	15	40	60	CEN- TER	2 μ m	22.9
							EDGE	10 μ m	24.4
EXAMPLE E2	SF ₆ /O ₂ / SiF ₄ (150/90 /50)	170	1400	15	40	30	CEN- TER	1 μ m	31.9
							EDGE	2 μ m	34.3
EXAMPLE E3	SF ₆ /O ₂ / SiF ₄ (150/90 /50)	250	2000	15	40	30	CEN- TER	10 μ m	36.3
							EDGE	1 μ m	23.4
							CEN- TER	2 μ m	25.3
							EDGE	10 μ m	26.3
							CEN- TER	1 μ m	30.7
							EDGE	2 μ m	33.0
							CEN- TER	10 μ m	34.5
							EDGE	1 μ m	23.1
							CEN- TER	2 μ m	25.6
							EDGE	10 μ m	26.8
							CEN- TER	1 μ m	26.4
							EDGE	2 μ m	28.9
							CEN- TER	10 μ m	31.2
							EDGE	1 μ m	16.94

FIG. 22

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1.2 μ m-WIDTH TRENCH ETCH

ETCHING GAS FLOW RATE (sccm)	PRES- SURE (mTorr)	RF POWER (W)	BACK PRESSURE (Torr)		TIME (sec)	LOCA- TION	TRENCH LENGTH	Si ETCH SELEC- TIVITY (Si/SiO ₂)	Si E/R (μ m/mi- n)	TAPER ANGLE (deg.)
			CEN- TER	EDGE						
EXAMPLE E4	SF ₆ /O ₂ / SiF ₄ (150/90/ 350)	170	1400	15	30	CENTER	1 μ m	52.9	9.25	88.7
						2 μ m	56.8	9.95		
					10 μ m		62.1	10.88	88.8	
					1 μ m		57.7	10.00	88.6	
EXAMPLE E5	SF ₆ /O ₂ / SiF ₄ (150/90/ 350)	170	1400	15	40	EDGE	2 μ m	62.6	10.86	
						10 μ m	67.5	11.69	89.0	
					1 μ m		37.9	7.39	88.7	
					2 μ m		43.8	8.54		
EXAMPLE E5	SF ₆ /O ₂ / SiF ₄ (150/90/ 350)	170	1400	15	40	80	CENTER	10 μ m	47.0	9.16
					1 μ m	EDGE	2 μ m	50.7	9.02	88.6
					10 μ m		54.8	9.75	88.5	

FIG. 23